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GIS Internet Map Service For Displaying Selenium Contamination Data In The Southeastern Idaho Phosphate Mining Resource Area

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GIS INTERNET MAP SERVICE FOR DISPLAYING SELENIUM CONTAMINATION DATA IN THE SOUTHEASTERN IDAHO PHOSPHATE MINING RESOURCE AREA

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ABSTRACT

Selenium is present in waste rock/overburden that is removed during phosphate mining in southeastern Idaho. Waste rock piles or rock used during reclamation can be a source of selenium (and other metals) to streams and vegetation. Some instances (in 1996) of selenium toxicity in grazing sheep and horses caused public health and environmental concerns, leading to Idaho Department of Environmental Quality (DEQ) involvement.

The Selenium Information System Project is a collaboration among the DEQ, the United States Forest Service (USFS), the Bureau of Land Management (BLM), the Idaho Mining Association (IMA), Idaho State University (ISU), and the Idaho National Laboratory (INL)[2]. The Selenium Information System is a centralized data repository for southeastern Idaho selenium data. The data repository combines information that was previously in numerous agency, mining company, and consultants' databases and web sites. These data include selenium concentrations in soil, water, sediment, vegetation and other environmental media, as well as comprehensive mine information. The Idaho DEQ spearheaded a selenium area-wide investigation through voluntary agreements with the mining companies and interagency participants. The Selenium Information System contains the results of that area-wide investigation, and many other background documents. As studies are conducted and remedial action decisions are made the resulting data and documentation will be stored within the information system. Potential users of the information system are agency officials, students, lawmakers, mining company personnel, teachers, researchers, and the general public. The system, available from a central website, consists of a database that contains the area-wide sampling information and an Environmental Systems Research Institute (ESRI) ArcIMS map server. The user can easily acquire information pertaining to the area-wide study as well as the final area-wide report. Future work on this project includes creating custom tools to increase the simplicity of the website and increasing the amount of information available from site-specific studies at 15 mines.

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[2] On February 1, 2001 the Idaho National Engineering and Environmental Laboratory (INEEL) ceased to exist, and the Idaho National Laboratory was born, combining the research and development activities of the INEEL with those of the former Argonne National Laboratory-West. The new INL (http://www.inl.gov/) is operated for the U.S. Department of Energy by Battelle Energy Alliance.

INTRODUCTION

Phosphate mining is an important contributor to the economy of southeastern Idaho. Southeastern Idaho lies within the Western Phosphate Field that covers portions of Idaho, Utah, Montana and Wyoming. The portion of the Field in Idaho is referred to as the Southeastern Idaho Phosphate Mining Resource Area. Phosphate is the largest industrial mineral produced in Idaho. Idaho production of phosphates constitutes over 12% of the national production. Currently there are four open pit operations that produce over 5.4 million metric tons of ore per year. Its industrial uses are largely for fertilizer and pure phosphate for phosphoric acid (Blanchard, 2002).

Mountain men and fur traders began exploration of southeastern Idaho in the early 1800's, and from about 1841 to 1870, emigrants on their way to the Oregon Territory passed through the area around Soda Springs on the Oregon Trail. Mineral exploration of the area took place in the 1870's, and phosphate deposits were recognized in the late 1800's and early 1900's. Phosphate mining began around 1907, but major production did not take place until the 1940's (Lee, undated).

Selenium is a naturally occurring mineral element that is distributed widely in most soil and rocks. Low levels of selenium occur naturally in the environment as a result of weathering of rocks and soil. It is an essential trace nutrient for human and animal health, and may be used as a nutritional supplement in low doses. Exposure to levels greater than those needed for good health can be harmful (ATDSR 2003). Selenium can be released in waste materials from a variety of activities including certain mining, agricultural, petrochemical, and industrial manufacturing operations. Once in the aquatic environment, it can attain levels that are toxic to fish and wildlife due to bioaccumulation in food chains (Lemly 2004).

Selenium is present in waste rock or overburden that is removed during phosphate mining in southeastern Idaho. It is normally present in the overburden in the relatively insoluble selenide form, or as elemental selenium, but after weathering and oxidation, it can produce the more soluble selenite or selenate forms. Waste rock piles or rock used during reclamation can be a source of selenium to streams and vegetation, and some streams near the phosphate mining area have been reported to be impacted by elevated levels of selenium (Hamilton and Buhl, 2004). Figure 1 shows the location of the phosphate mining area.

BACKGROUND

The following paragraphs are excerpted and paraphrased from Jones and Buck, 2004 to give a history of selenium contamination and the regulatory environment leading to the many studies and reports related to the problem that are or will be available:

Selenium contamination led to numerous studies

In December1996, six horses grazing on private land downstream from a phosphate mine in Caribou County, Idaho became ill and were diagnosed with chronic selenosis (selenium poisoning); five of these animals had to be destroyed. In the summer of 1997, two horses

pastured on another inactive phosphate mine were also diagnosed with selenosis and had to be destroyed. In mid-summer 1997, 176 sheep were found dead in this same area. The cause of death was not confirmed but selenium poisoning was not ruled out. Other occurrences of multiple sheep deaths have been reported at phosphate mines in the area. In 2003, sheep began to die within 72 hours of their exposure to highly seleniferous native plants growing down gradient of a reclaimed phosphate mine. Forensic examination in each case showed elevated selenium concentrations in tissue and rumen although definitive conclusions as to the actual cause of the deaths were not made until 2003.

The publicity related to the selenosis in the horses prompted agency and public concerns that selenium releases from phosphate mining was apparently an environmental and potential public health concern in southeastern Idaho. Five phosphate mining companies in southeastern Idaho quickly accepted that the selenium contamination problem was a significant concern and could be systemic throughout the phosphate mining region. The five companies formed an ad hoc committee of the Idaho Mining Association (IMA). Members of the IMA Selenium Subcommittee joined voluntarily with representatives from the land management, environmental, and resource management agencies to form the "Selenium Working Group" to provide oversight of planned investigations. The IMA Selenium Subcommittee agreed to fund regional studies intended to identify selenium sources and the extent of selenium environmental impacts. The initial role of the Selenium Working Group was to direct data collection strategies, identify specific studies, interpret data, and cooperate with the phosphate mining industry to develop mitigation or management practices to prevent selenium releases from current and future phosphate mining operations. Participating agencies initially included:

- *United States Forest Service (USFS)*
- *United States Bureau of Land Management (BLM)*
- *Idaho Department of Environmental Quality (IDEQ)*
- *Idaho Department of Lands (IDL)*
- *Idaho Department of Fish and Game (IDFG)*

Later in the process several other agencies and sovereign parties joined in the process but remained outside the working group. They included:

- *U.S. Fish and Wildlife Service (USFWS)*
- *U.S. Environmental Protection Agency (EPA)*
- *U.S. Bureau of Indian Affairs (BIA)*
- *Shoshone-Bannock Tribes*

Members of the IMA Selenium Subcommittee and their consultant produced a number of documents related to regional investigations performed throughout a 2,500 square mile area in southeastern Idaho.

In addition to what the Selenium Subcommittee was doing, other organizations were conducting separate studies, including: University of Idaho conducted studies to identify or refine environmental and selenium treatments at a mine; another mining company conducted independent field studies at their mine of selenium accumulation in vegetation; three of the mining companies conducted multi-media environmental baseline studies at their properties, focusing on the selenium impacts, to support upcoming Environmental Impact Statements (EISs);

the USFS' Rocky Mountain Research Station started research to identify vegetation species adapted to reclamation purposes that would occlude selenium; the IDEQ began Total Maximum Daily Load (TMDL) studies on known impacted watersheds in the region; and the USGS Western Mineral Resources Team, Western U.S. Phosphate Project, began a 5-year study in 1997 that included investigations of the geology, mineralogy, history, stratigraphy, chemistry and environmental characteristics of many phosphate mining locations in southeastern Idaho. Altogether, these studies generated a tremendous amount of information in only 3-4 years on the source, pathways, and impacts of selenium contamination related to phosphate mining. This was a major accomplishment through industry and agency cooperation. Although the regulatory agencies appreciated the phosphate mining industry's voluntary effort, the agencies decided that the completely voluntary efforts to date on the part of the mining companies would have to be replaced with a more traditional, agency-controlled approach using State and Federal authorities.

Memorandum of Understanding

In July, 2000, the Federal regulatory agencies participating in the actions of the Selenium Working Group (USFS, BLM, EPA, USFWS, BIA), the IDEQ, and the Shoshone-Bannock Tribes entered into a formal agreement between them titled the, "Memorandum of Understanding concerning Contamination from Phosphate Mining Operations in Southeastern Idaho" (MOU). The stated purpose of this agreement provided a cooperative atmosphere for the regulatory parties to work together on matters related to environmental contamination at phosphate mines. Parties to the MOU agreed that an area-wide contamination investigation should be conducted by the IDEQ under the criteria and scope of work established in the MOU. This would be done through an "Administrative Order on Consent" (AOC) with the members of the IMA Selenium Subcommittee principally responsible for the leases in Southeastern Idaho. The AOC had an agreement that subsequent site-specific investigations and remedial actions, conducted under CERCLA and other regulatory authorities, would not duplicate efforts conducted under the area-wide investigations. Site-specific investigations would be managed by agreed upon lead agencies, with identified support agencies. Lead agencies would enter into site-specific, enforceable agreements with the affected companies for each individual mine site.

In signing this MOU, the agencies asserted their regulatory authority under CERCLA to take charge of the regional contamination impact investigations, now called the "Area-wide Investigations" and eventually conduct whatever site-specific studies were necessary to thoroughly investigate all the 15 major operating and inactive phosphate mines for the release or threatened release of hazardous substances. Site Investigations (SIs) and Engineering Evaluation/Cost Analyses (EE/CAs) would eventually lead to other agreements implementing selected alternatives to effectively manage or prevent contaminant releases.

One might think the mining companies would object to this change in approach; this has not been the case. Each of the involved mining companies supported this change for individual reasons related to their continued ability to produce phosphate ore from their leases in southeastern Idaho. Their cooperation demonstrates their commitment to operate within reasonable and informed environmental protection measures for sustained land management. There is a general recognition that without this commitment to care for public lands, citizen

opposition could stifle their continued mining in the area. Additionally, industry cooperation in regional studies leading to site-specific investigations offers the prospect of a more effective process, reduced costs, and systematic decision-making.

Area-Wide Consent Order and Administrative Order on Consent

In concert with the interagency MOU and the CERCLA process, the parties to the MOU negotiated an enforceable Area-wide Consent Order and Administrative Order on Consent (CO/AOC) with the mining companies. The Area-wide Investigation outlined in the CO/AOC identifies procedures to be used for human health and ecological risk assessments that will support a risk management plan intended to focus site-specific investigations on identified mechanisms and pathways releasing contaminants into the environment. With the signing of the Area-wide CO/AOC in September 2001, IDEQ began work on the area-wide investigations.

Area-Wide Investigations

An Area Wide Scope of Work was developed that utilized information from earlier IMA regional investigations and continued work envisioned in the MOU. The Scope of Work included:

- *Assess all existing data and prepare a preliminary risk assessment,*
- *Determine data needs to support an area wide human health and ecological risk assessment,*
- *Develop sampling and analyses plans and studies to fill identified data gaps,*
- *Conduct area-wide investigations as required,*
- *Complete area-wide, population-based ecological and human health risk assessments,*
- *Establish remediation goals, remedial action objectives, and risk based cleanup levels,*
- *Develop a regional water quality and aquatic monitoring plan,*
- *Develop best available technology and response techniques*

IDEQ sought public input at all major steps in the area-wide process. Public meetings were held, notices were published in local newspapers and on IDEQ's Internet site, and major study plans and draft documents were posted on the IDEQ website providing interested citizens the opportunity to participate. Early involvement came mostly from agency representatives and the IMA; however, as the risk assessment and management plans became available, elements of the public became increasingly involved. (IDEQ, 2002)

Site-specific Investigations

Site-specific investigations mentioned in the MOU will be planned by oversight agencies and the potentially responsible parties. With one exception, the Forest Service will be the lead agency on all mine sites that are located within the boundaries of the Caribou-Targhee National Forest. The IDEQ will be the lead agency where the surface is privately owned or where private land is intermingled with BLM or State surface ownership. The BIA will be the lead agency where the surface ownership is tribal. Other parties to the MOU will be "Support Agencies" ensuring that lead agencies provide for their interests as appropriate for each site. The scope of work for each site-specific CERCLA project would include the following major tasks:

- *Develop a Project Work Plan,*
- *Prepare and implement a Community Relations/Public Involvement Plan,*

- *Oversight of the Site Investigation Work Plan,*
- *Oversight of the Sampling and Analysis Plan,*
- *Oversight of the Quality Assurance Project Plan,*
- *Oversight of the Health and Safety Plan,*
- *Oversight and approval of the Site Investigation,*
- *Oversight of the Risk Assessment,*
- *Oversight of the Engineering Evaluation/Cost Analysis and remedial alternative selection,*
- *Monitoring Oversight of Selected Alternatives, and*
- *Review of technical and progress reports.*

SELENIUM INFORMATION SYSTEM PROJECT

Purpose

From the background information above, it is clear that a tremendous amount of data has been collected related to selenium contamination from phosphate mining in southeastern Idaho. Data have been collected by mining companies and their consultants, by numerous State and Federal agencies and their consultants, by university researchers and others. Many types of media have been sampled and analyzed (e.g., water, soil, sediment, vegetation, fish, animal tissue, etc.) over a broad region during area-wide investigations conducted in the last several years; some area-wide monitoring data will continue to be collected. These data exist in a variety of databases and have been available (in hard copy or electronically) from numerous sources, including agency or company web sites. Even more data and reports will be collected as the effort has moved into the site-specific phase where remedial actions will be selected at 15 mining sites. Although the focus of the effort (and the title of this project) is on selenium, most of the samples that have been collected were also analyzed for a suite of other analytes, such as cadmium, calcium, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, etc. From the toxicity screening that was done in the Area-Wide Risk Assessment, it was determined that the contaminants of concern (COC) for future site-specific activities will be cadmium, chromium, copper, nickel, selenium, vanadium and zinc. Selenium and cadmium are considered to be the primary hazard drivers on a regional basis.

Thus, an abundance of information is available to mining companies, regulatory and other agencies, and the public, but it is not always easy to find nor available in one location. Searching for and providing information to interested parties can be time consuming for agency personnel, and it is possible that not all agencies have access to the same information. Simply stated, the purpose of the Selenium Information System Project (SISP) is to provide an Internet based information management system where pertinent data can be retrieved and displayed graphically from one web site.

Idaho National Laboratory (INL) and Idaho State University (ISU) Collaboration

Several years ago, INL personnel visited parts of Idaho and surrounding states and asked agencies, universities, and Congressional delegations or staff what some of their environmental issues or concerns were and how might the INL help to resolve those issues (INEEL, 2001). One suggestion was that the INL and ISU should collaborate and become engaged in selenium

contamination issues from phosphate mining in southeastern Idaho. INL and ISU discussions with agency personnel involved with that issue identified the need for assistance in managing the data and reports being produced in current area-wide and future site-specific investigations.

Using internal funds, INL and ISU performed a preliminary evaluation of the data and information needs and developed a prototype, Geographic Information System (GIS), internet map service for retrieving and displaying data. Only limited data were available from this prototype, but it served as the basis for further demonstrations and discussions with State and Federal agencies and representatives of the Idaho Mining Association. INL and ISU made refinements to the map service and discussions with the potential users continued. A SISP Steering Committee, made up of representatives from INL, ISU, IDEQ, USFS, BLM, and IMA, guided further development of the prototype while a source of funding for further development was sought. A technical committee, comprised of personnel from the same organizations who have more day-to-day involvement with the data or GIS information, was also established.

In June of 2004, an Interagency Agreement was signed between the U.S. Department of Energy (DOE), Idaho Operations Office and the U.S. Environmental Protection Agency, Region 10 to provide funding for further development of the prototype SISP to improve its functionality and add additional data. Both DOE and EPA are ex-officio members of the SISP Steering Committee and participate in regularly scheduled committee meetings as time permits.

The Selenium Information System

The SISP consists of three main components: the website, the internet map server, and an associated database. All three components are seamlessly integrated. The current system is a functional prototype of the system being developed.

The website, shown in Figure 2, is the entry point for the entire information system. It contains general information about the project and contact information for all agencies involved with the project. It also provides contact information for members of the technical and steering committee, and access to reports generated during the area-wide study, that are available for download through the website. As the site-specific reports are completed, each one will be added to the website and made available for download.

One of overall goals of the project is to simplify the process of gathering and disseminating information being collected by the various agencies, universities and others. In order to simplify the maintenance and up-keep of the website, a content management system (CMS) is in development. This CMS will allow members of the steering committee to add or manage website content without requiring any special web programming skills. As new reports are completed, the steering committee members can easily upload them to the website. Once the system is fully built, the cost of maintenance will be low because the skills of a programmer are not required to maintain the content.

The SISP map server – a spatial and tabular information management system for retrieval and graphic display - is accessible through the website (Figure 3). Eventually, it will contain all data and sample results published in the area-wide and site-specific reports. Currently, however, the

map server contains data layers pertaining to water, plant, and soil samples along with specific geographic boundaries and planimetric features such as mine boundaries, land ownership, municipalities, roads, hydrography, counties, and topography. During the next year, more data will be added including fish, elk and bird egg studies.

Internet map servers like the SISP map server allow users to visually query data. Simple functionality includes zooming, panning, printing and selecting. Advanced functionality includes querying, buffering, measuring, and identifying map features. The map server allows the user to query specific data sets and the results are returned visually on the map as well as in tabular format. In the future, the data will be available as an Excel sheet or a comma delimited file so the user can manipulate the data any way they wish. All geographic data contained within the map server are available for download. This allows more advanced users the ability to manipulate the data in their software of choice. Future work on the map server includes customization of the advanced tools.

The map server is the interface to the database component. A user clicks on a particular sample to view the associated data in the database. Once the sample is selected, the user is presented with a menu of tables (shown in Figure 4). Eventually, all data available for that particular sampling location will be displayed in the tables. During this year, the database interface will be customized extensively to increase its functionality and make it easier to use, especially for individuals who may have limited experience with either GIS or databases.

Although the development of the SISP is not complete, it is available for use in its current form at the following address: http://giscenter-ims.isu.edu/SISP/selenium.htm.

ACKNOWLEDGEMENTS

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FIGURES

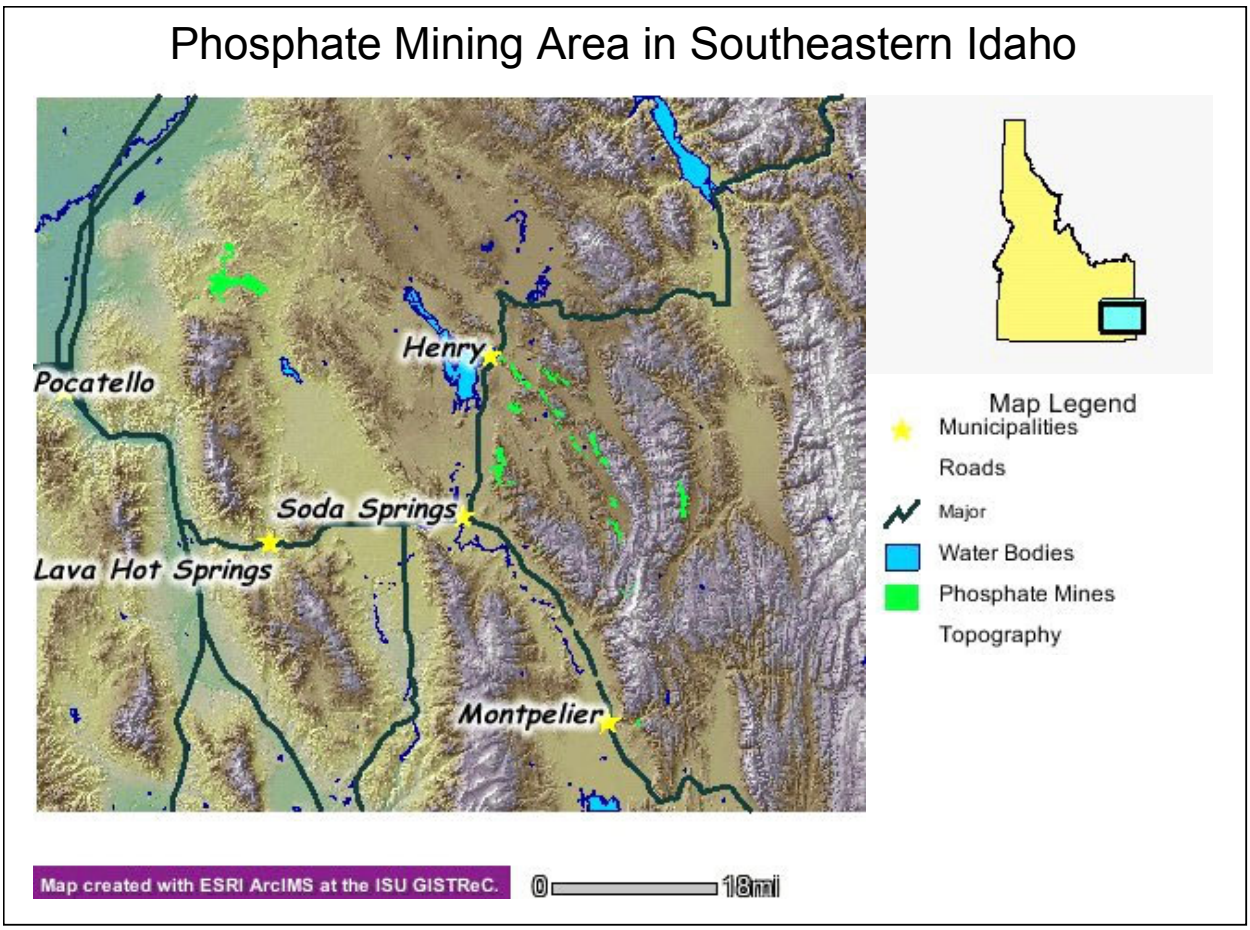

Figure 1: This map displays the region covered by the selenium information system project.

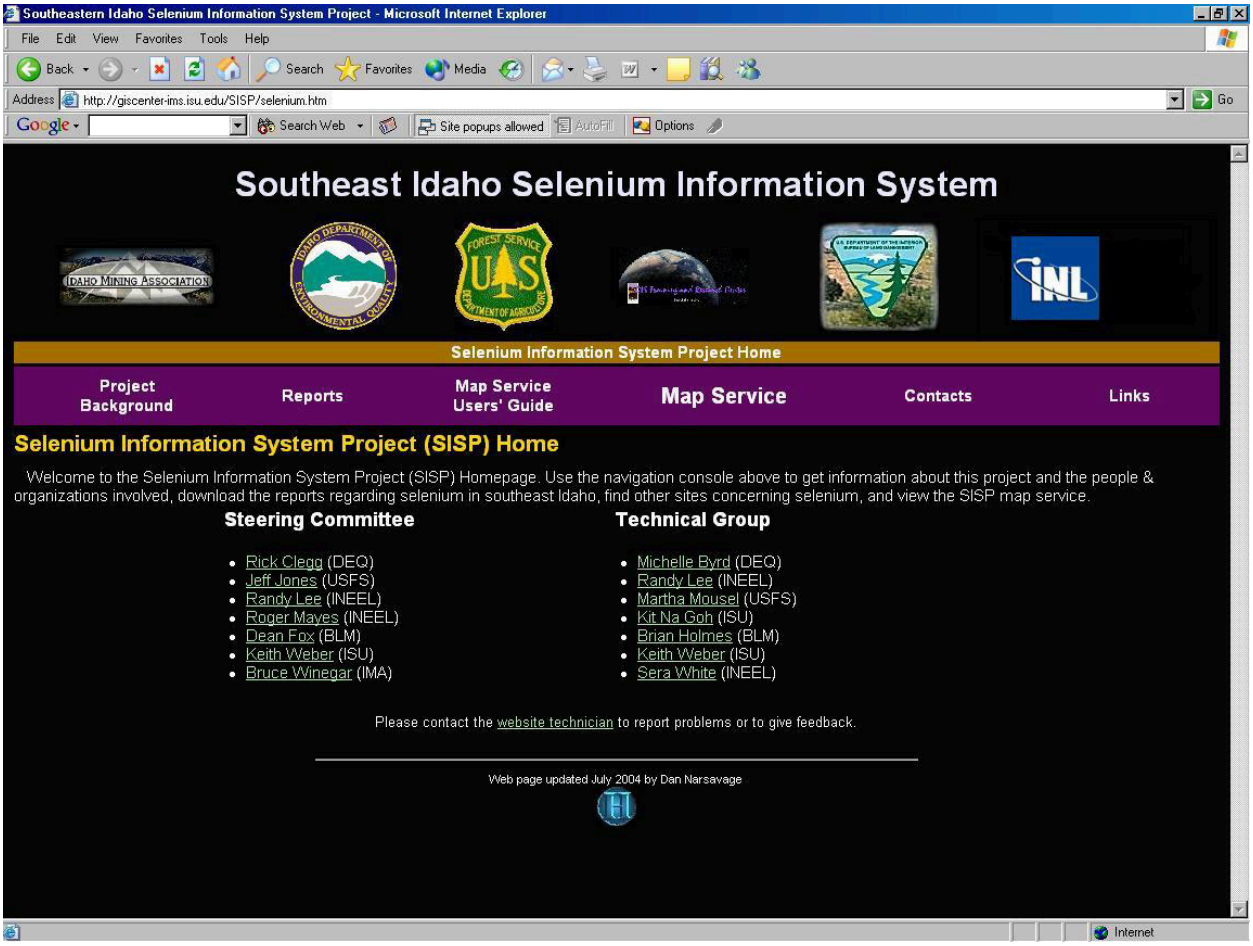

Figure 2: A screenshot of the main entry page of the website.

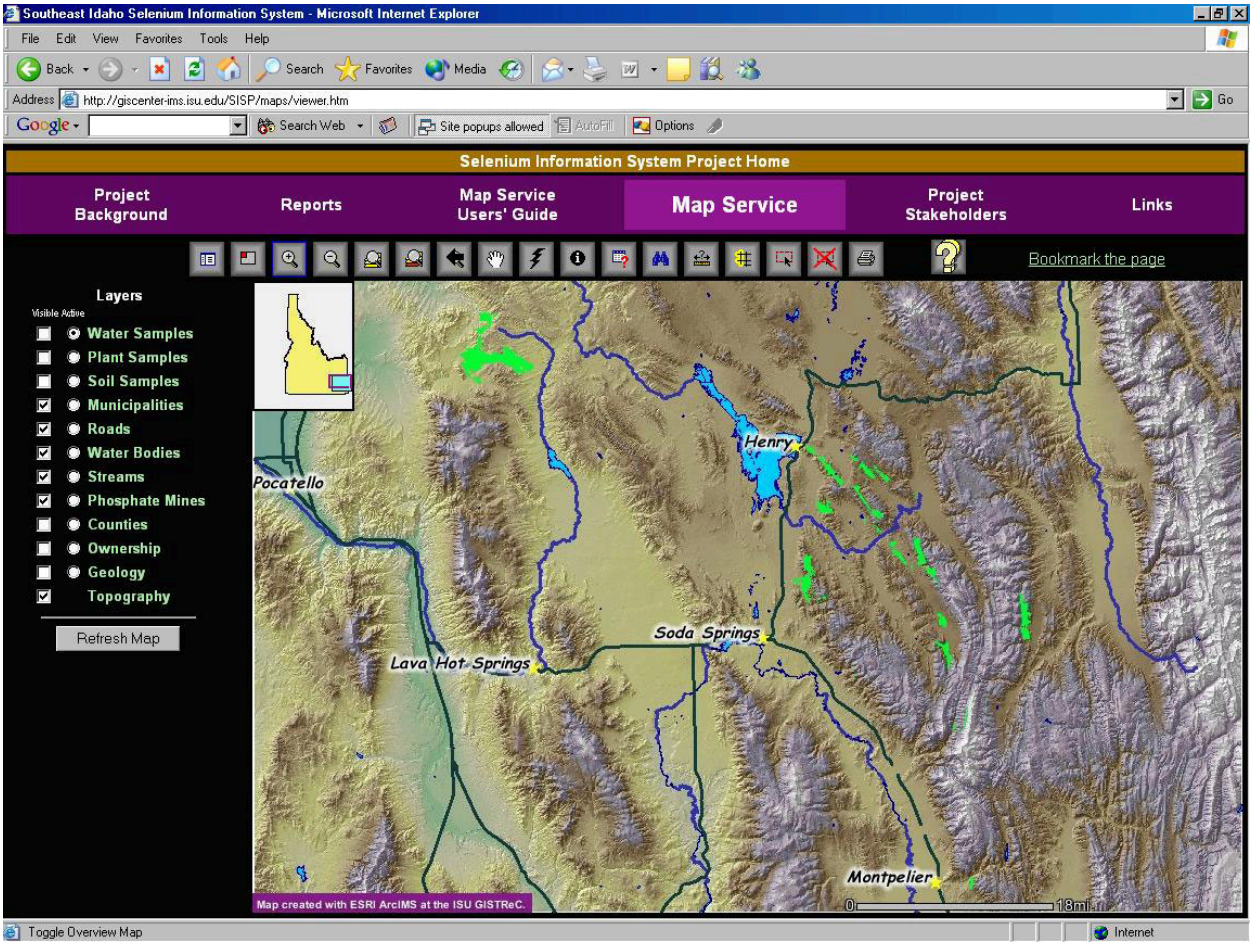

Figure 3: A screenshot of the map server.

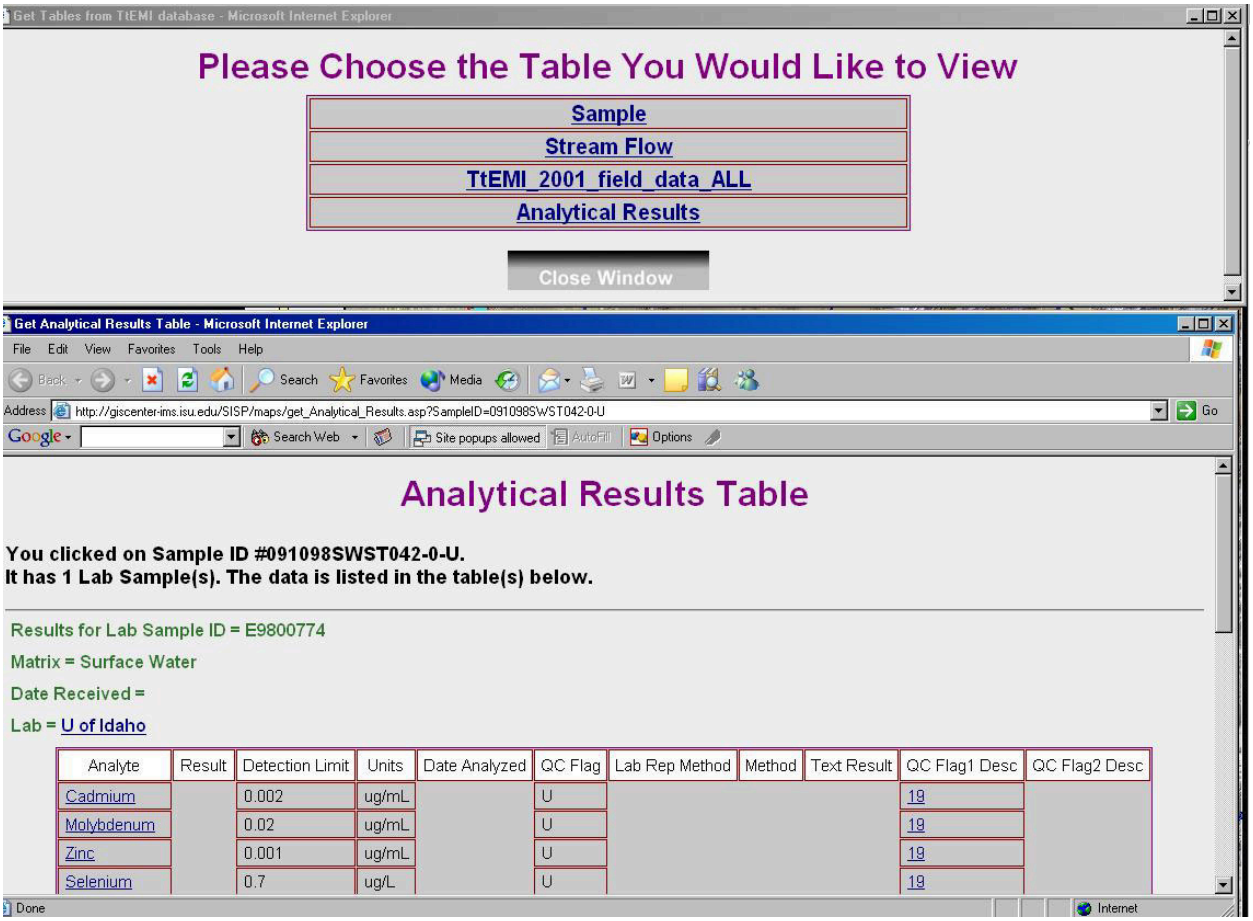

Figure 4: A screenshot showing the database. Here the table Analytical Results has been selected from the table menu and is displayed in the lower portion of the figure.